



## PATENT SPECIFICATION

DRAWINGS ATTACHED

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## COMPLETE SPECIFICATION

## Improvements relating to Gas Reforming Plants

We, NORTH WESTERN GAS BOARD, a British Corporation, of Bridgewater House, 60, Whitworth Street, Manchester 1, Lancashire, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method and apparatus for producing fuel gases by reforming gaseous or liquid hydrocarbons in which the feedstock is treated with steam in the presence of a catalyst, and the treated gas is passed through a shift converter to reduce its carbon monoxide content.

The object of the invention is to provide means for controlling the temperature of the gas entering the shift converter, so that the gas leaving the reformer at 800–850°C, is cooled to 350–400°C before it enters the shift converter.

According to the invention, a portion of the reformed gas is passed through a waste heat boiler and thereby cooled, and is then added to the remainder of the reformed gas before it enters the shift converter, the temperature being regulated by controlling the amount of gas passed through the waste heat boiler.

In a convenient arrangement of plant for carrying out the invention, controlled quantities of hydrocarbon feedstock and air are burnt in a reactor; this heats the reactor catalyst bed. The hot waste gases are passed through one section of a waste heat boiler which has been divided into two parts. A valve giving access to a chimney is open and the now cool waste gases pass to the atmosphere up the chimney. When the catalyst bed in the reactor has reached the desired temperature, the air supply is shut off, and after a short purge with steam, the chimney valve is closed. Hydrocarbon feedstock and steam are now passed through the

reactor catalyst bed and are converted to gas containing carbon monoxide.

This hot gas now divides into two streams, one of which passes through the above-mentioned one section of the waste heat boiler and is there cooled. A cyclic valve is opened and allows the cooled gas to flow into a cool gas main. The gas is caused to flow through this main by steam, required for the carbon monoxide shift reaction, being used in the manner of an injector. An alternative means of inducing gas flow through the cool gas main is by a fan, or by the formation of a venturi throat in the hot gas main at the outlet from the reactor.

The cool gas is mixed with the stream of hot gas from the reactor, and the temperature of the mixed gas is controlled by varying the quantity of gas cooled and mixed with the hot gas. The control point is a butterfly valve fixed between the cyclic valve and the steam injector. The control may be automatic from a sensing pyrometer in the mixed gas stream or the CO shift catalyst bed.

The CO content of the mixed gas is reduced by passage through the CO shift catalyst and the hot shifted gas passes through the second section of the waste heat boiler and through an automatic water seal in a scrubber, and after passing through water sprays, the cooled and washed gas leaves the plant.

In another convenient arrangement, a single pass waste heat boiler is used for cooling a proportion of the reformed gas, and a steam superheater is used to cool the gas leaving the shift converter.

Referring to the accompanying drawings, Figure 1 shows one embodiment of an apparatus according to the invention, during the heating phase.

Figure 2 shows the same embodiment during the production phase.

Figure 3 shows a modified arrangement.

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Referring to Figures 1 and 2, there is a reactor 1 with catalyst bed 2, inlets 3, 4, 5 for air hydrocarbon feed stock and steam, an outlet 6 to the lower section 7 of a waste heat boiler, and a pipe 8 to a CO shift converter 9 containing a catalyst bed 10. The converter 9 has an outlet 11 to the upper section 12 of the waste heat boiler, from which there is a pipe 13 to a gas scrubber 14. From the lower section 7 of the boiler a pipe 15 leads through a chimney valve 16 to a chimney 17, a branch pipe 18 with valve 19 and steam injector 20 leading to the pipe 8. A butterfly valve 21 is provided in the pipe 18.

During the heating phase air and feedstock are admitted at 3 and 4 and burn in the reactor 1 to heat the catalyst bed 2, the waste gases passing through the boiler section 7 to the chimney 17.

After the heating phase is completed, the plant is changed over to production by closing the chimney valve 17 and opening the valve 19, feedstock and steam being supplied at 4 and 5. Gas produced in the catalyst bed 2 flows through the shift converter 9 and the boiler section 12 to the scrubber 14. A part of the gas is diverted through the outlet 6 to the boiler section 7 and the pipe 18 to rejoin the main gas stream in the pipe 8. This part of the gas, the amount of which can be controlled by the butterfly valve 21, is cooled in the boiler section 7 and serves to control the temperature of the gas entering the converter 9. The gas produced passes from the scrubber 14 to the place of use.

In the modified arrangement shown in Figure 3, the waste heat boiler has only one section 7, through which gases from the reactor 1 flow to the chimney 17 or pipe 18 as before. The gas flowing through pipe 18 during the production phase enters the outlet pipe 8 from the reactor 1 and then enters a steam superheater 22 where the temperature of the whole gas stream is reduced to that required in the converter 9. From the converter 9 the gas flows through a superheater 23 to the scrubber 14, this superheater 23 replacing the upper boiler section 12 of Figures 1 and 2. The temperature of the gas entering the superheater 22 is controlled by varying the proportion of the gas produced in the reactor which is cooled by passing through the boiler 7.

The steam generated by the waste heat boiler and the superheaters (where used) can

be used in carrying out the process, and for driving the gas along the pipe 18 by means of the injector 20, thereby supplying the steam required for the CO shift reaction.

#### WHAT WE CLAIM IS:—

1. A method of producing fuel gas by reforming hydrocarbons, in which a portion of the reformed gas is passed through a waste heat boiler and thereby cooled, and is then added to the remainder of the reformed gas before it enters the shift converter, the temperature being regulated by controlling the amount of gas passed through the waste heat boiler.

2. A method as claimed in claim 1, in which the gas leaving the shift converter is cooled by passing through a section of the waste heat boiler or through a steam superheater.

3. Apparatus for carrying out the method claimed in claim 1 or 2, comprising a reforming reactor, a waste heat boiler, a CO shift reactor, means for supplying hydrocarbon feedstock and steam to the reforming reactor during the production phase and for feeding reformed gas to the shift converter, and means for passing a proportion of the reformed gas through the waste heat boiler and then adding it to the gas entering the shift converter.

4. Apparatus as claimed in claim 3, in which the waste heat boiler has two sections, the portion of the reformed gas to be cooled being passed through one section and the gas leaving the shift converter being cooled in the other section.

5. Apparatus as claimed in claim 3, in which the gas leaving the shift converter is cooled by being passed through a steam superheater.

6. Apparatus as claimed in claim 5, in which the reformed gas flows through a steam superheater before entering the shift converter.

7. Apparatus for carrying out the method as claimed in claim 1 or 2, substantially as described with reference to the accompanying drawings.

8. A method according to claim 1 for producing fuel gas by reforming hydrocarbons, substantially as described.

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